# Aquifer Management and Water Conservation

Eastern Carolina Environmental Conference

May 10, 2012

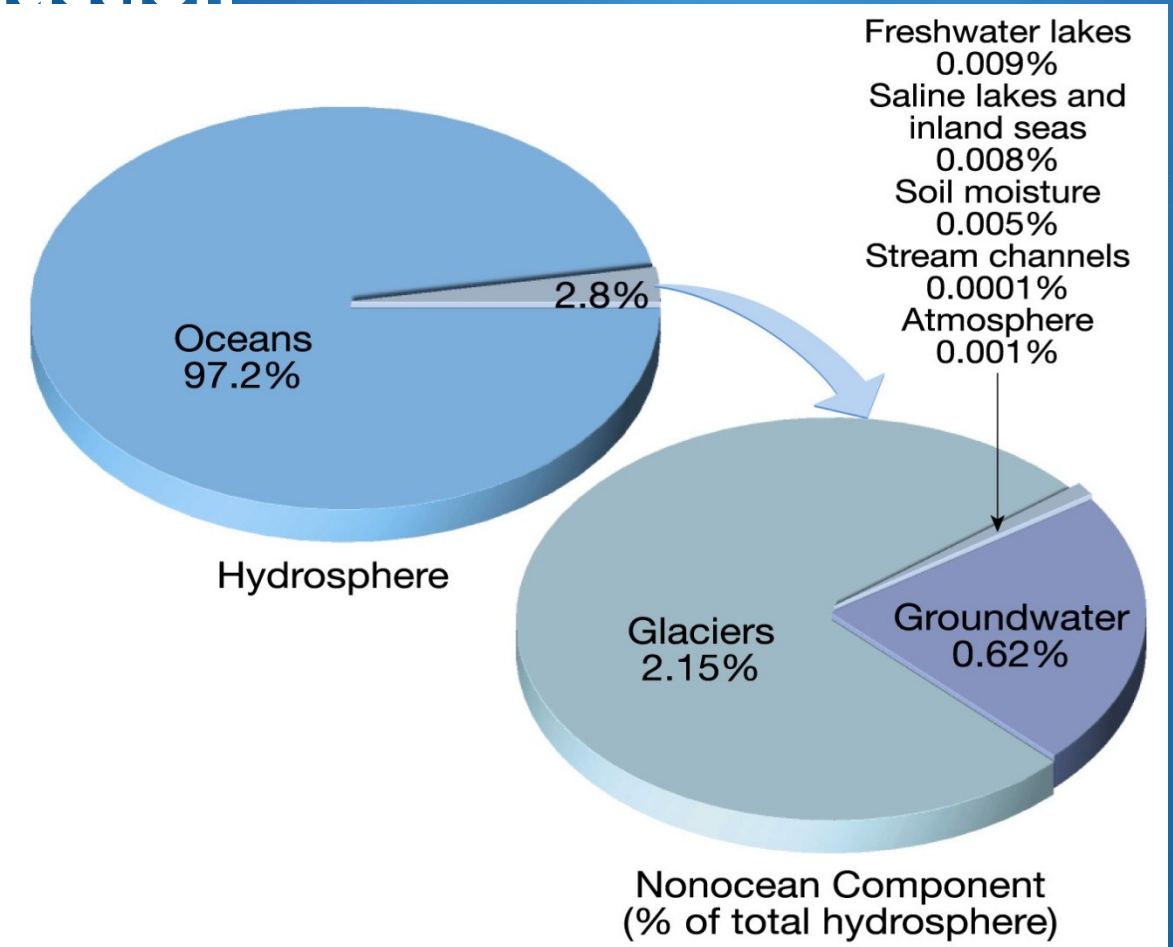
Evan Z. Bean, PhD

ECU Engineering

Go Coastal! icsp

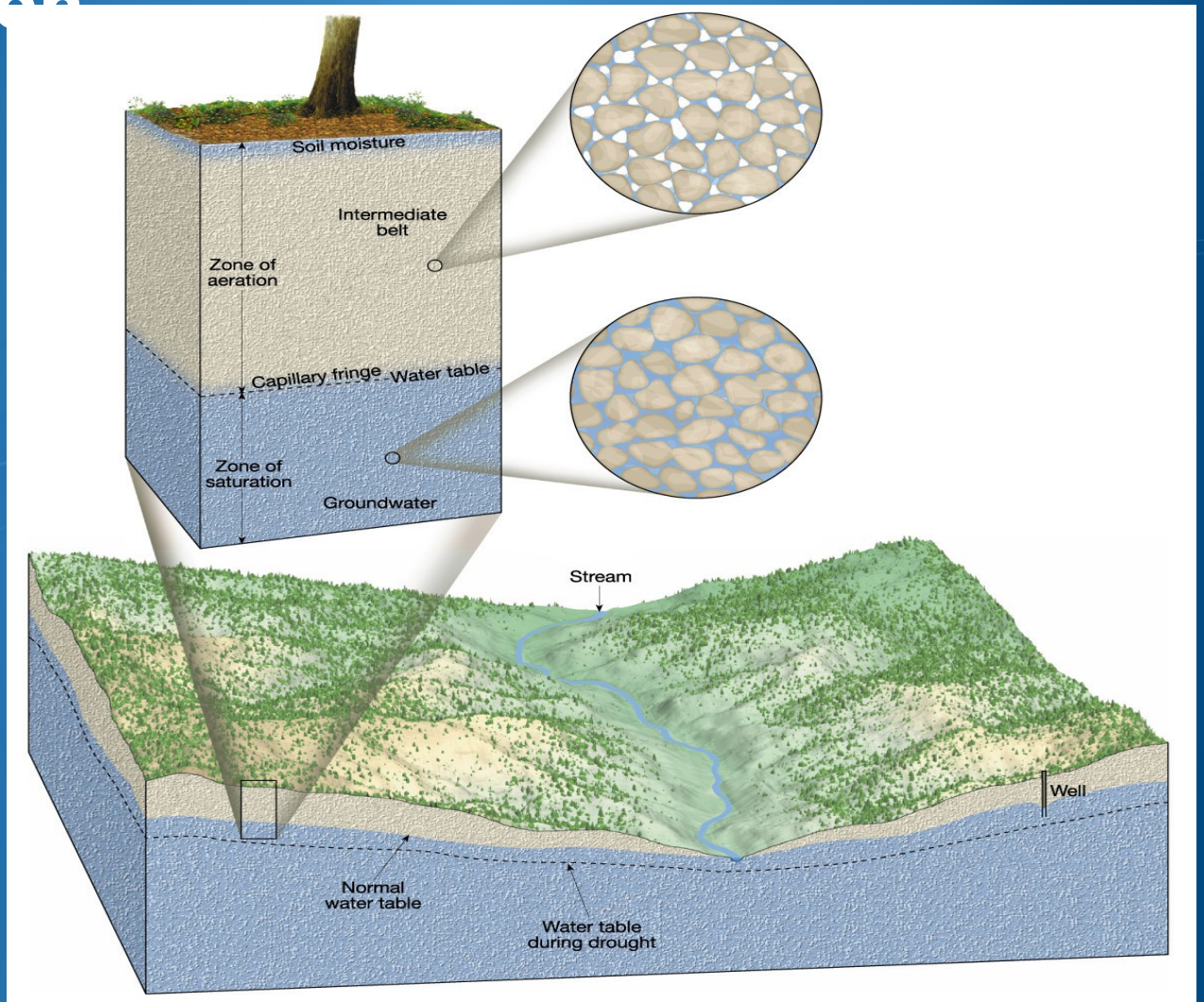
# Groundwater

- Largest reservoir of fresh water that is readily available
- Relatively Constant Quality and Production

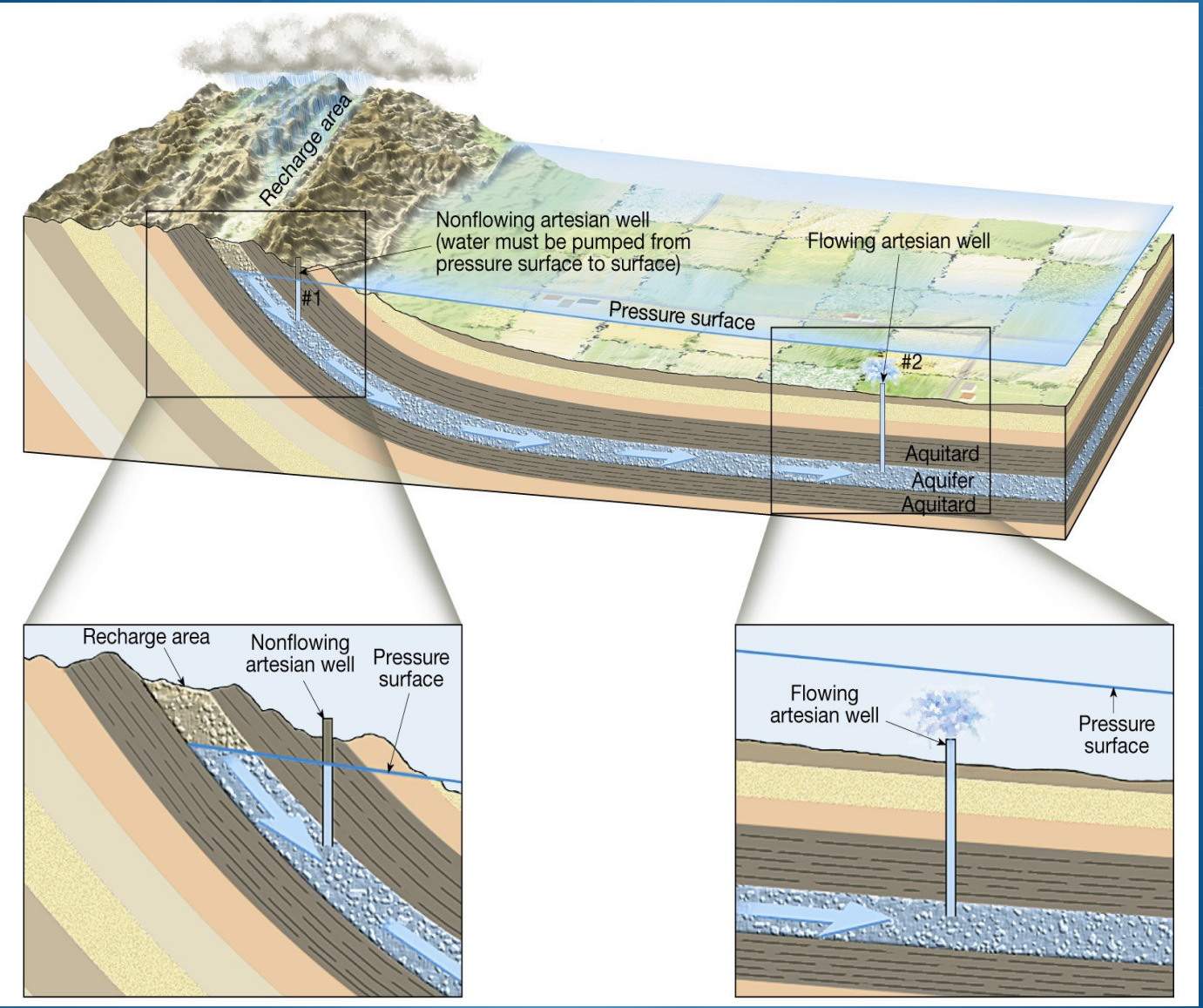


# Distribution of groundwater

- **Zone of saturation**
  - **Water table – the upper limit of the zone of saturation**



# Aquifer Geology



# Porosity

- **Porosity** – percentage of total volume of rock or sediment that consists of pore spaces

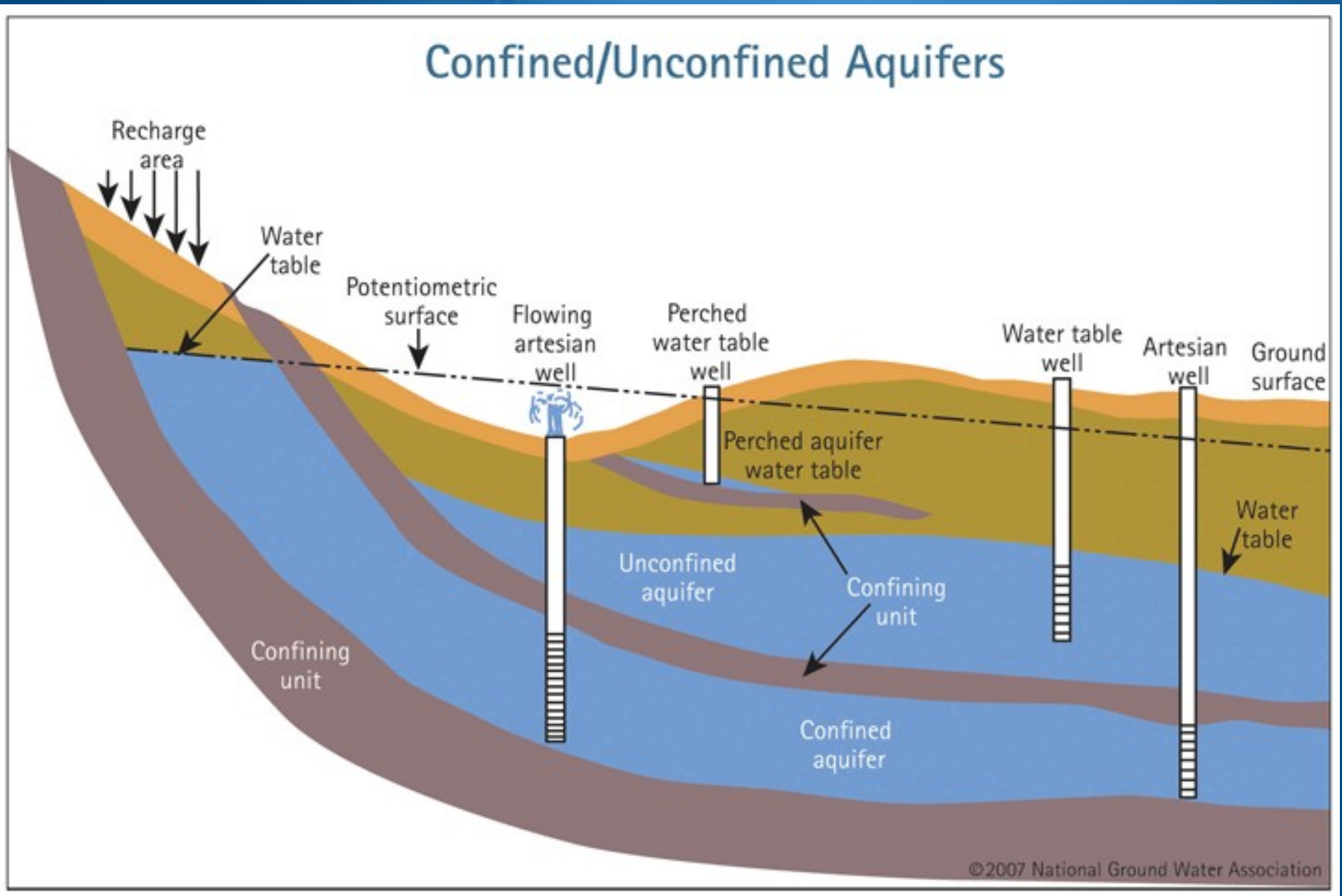
TABLE 11.2 **Selected Values of Porosity, Specific Yield, and Specific Retention***

| Material | Porosity | Specific Yield | Specific Retention |
|---|---|---|---|
| Soil | 55 | 40 | 15 |
| Clay | 50 | 2 | 48 |
| Sand | 25 | 22 | 3 |
| Gravel | 20 | 19 | 1 |
| Limestone | 20 | 18 | 2 |
| Sandstone (semiconsolidated) | 11 | 6 | 5 |
| Granite | 0.1 | 0.09 | 0.01 |
| Basalt (fresh) | 11 | 8 | 3 |

*Values in percent by volume

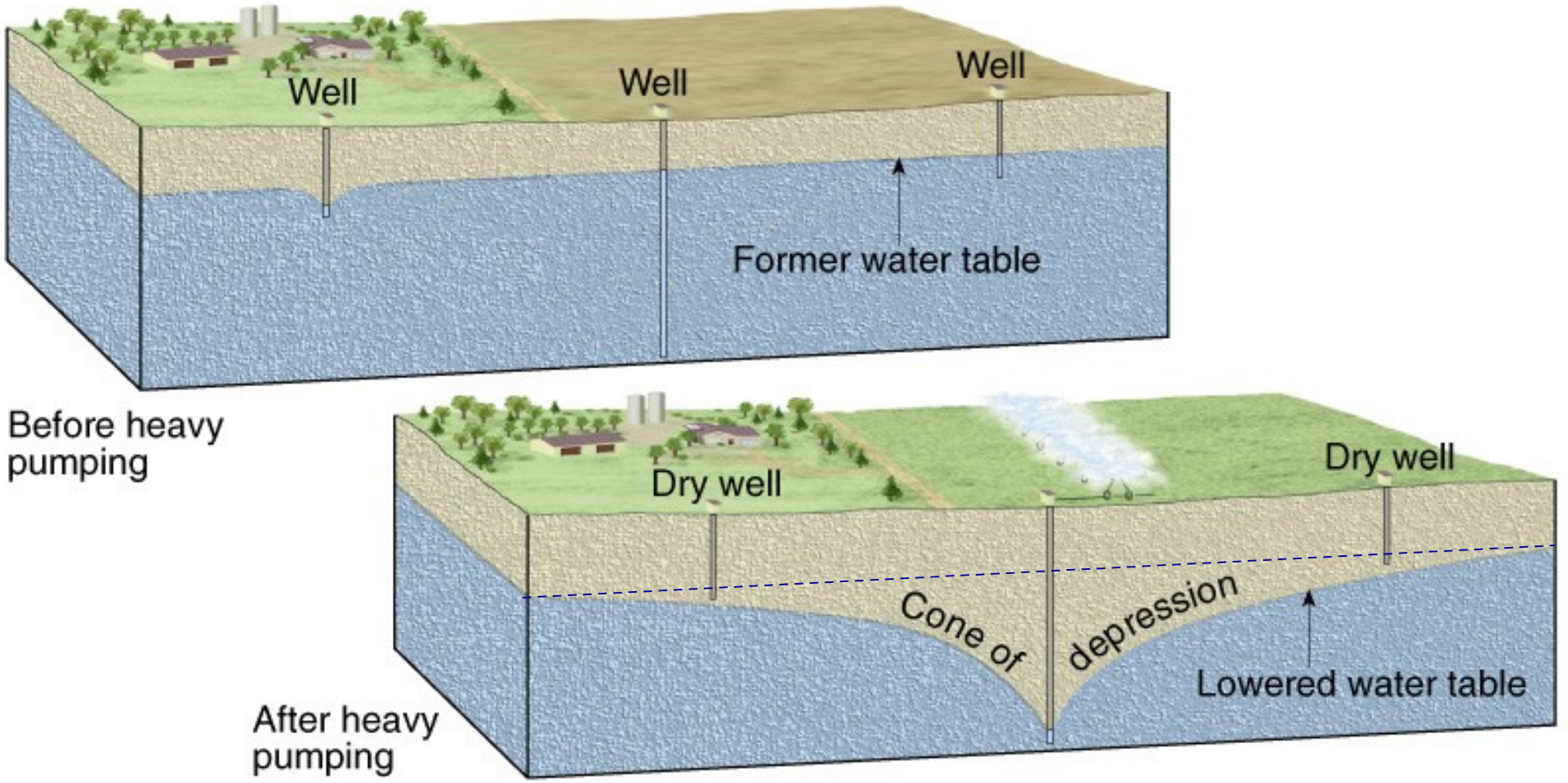
SOURCE: U.S. Geological Survey Water Supply Paper 2220, 1987

# Confined/Unconfined Aquifers



# Problems associated with groundwater withdrawal

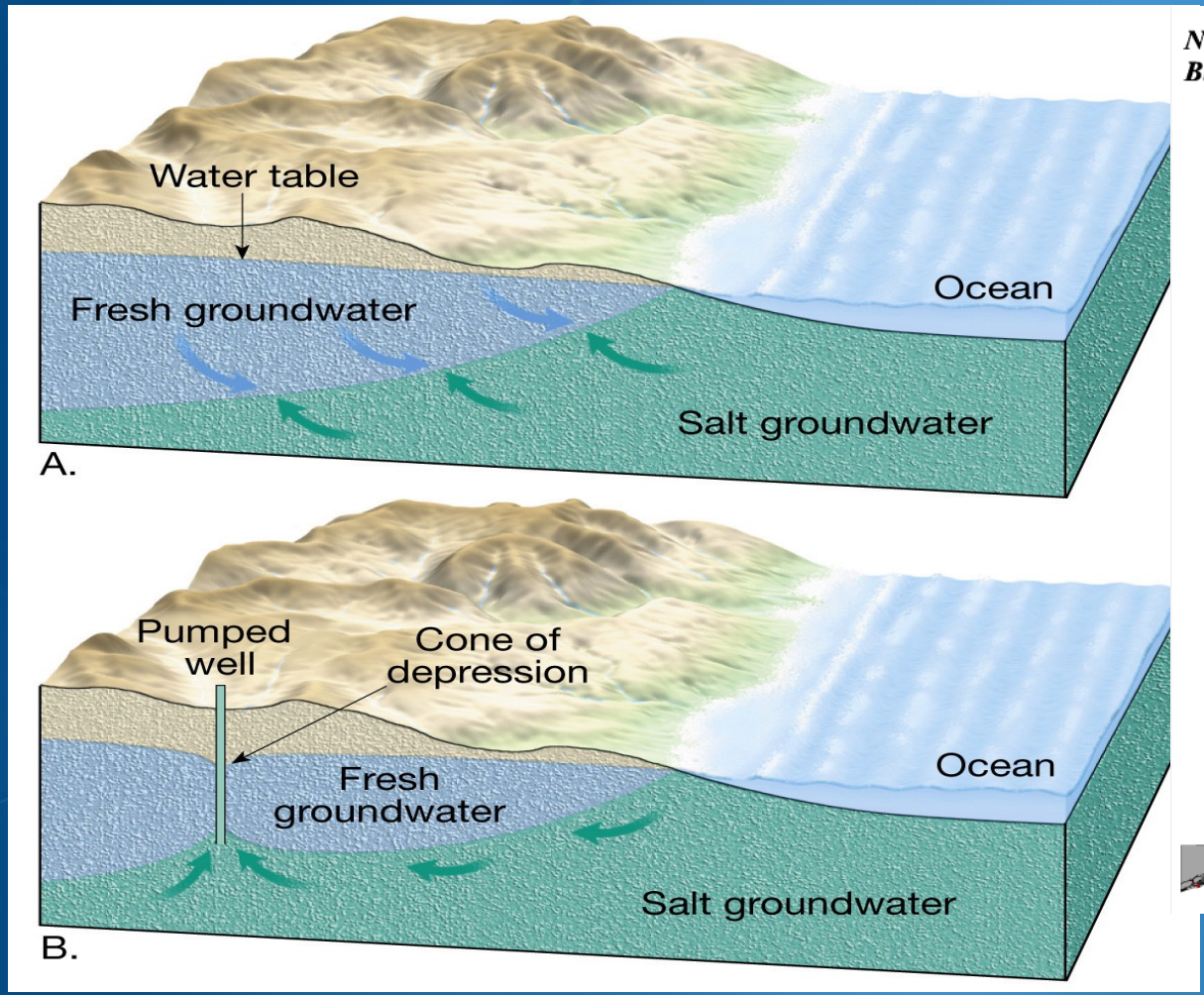
- Overpumping
  - In many places the water available to recharge the aquifer falls significantly short of the amount being withdrawn
- Subsidence
  - Ground sinks when water is pumped from wells faster than natural recharge processes can replace it
  - Coastal plain subsidence rate: 0.1 – 0.3 in/yr

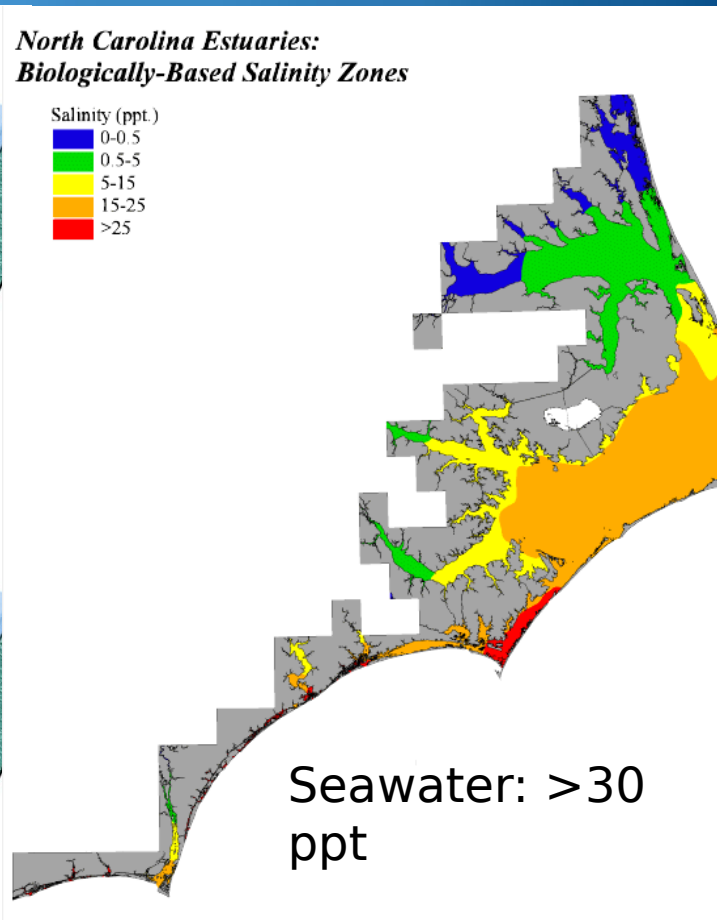

Well
Well
Well
Former water table
Before heavy pumping
Dry well
Dry well
Cone of depression
Lowered water table
After heavy pumping

# Problems associated with groundwater withdrawal

- **Saltwater intrusion/contamination**
  - **Excessive groundwater withdrawal causes saltwater to be drawn into wells, thus contaminating the freshwater supply**
  - **primarily a problem in coastal areas**

# Saltwater contamination due to excessive well pumping



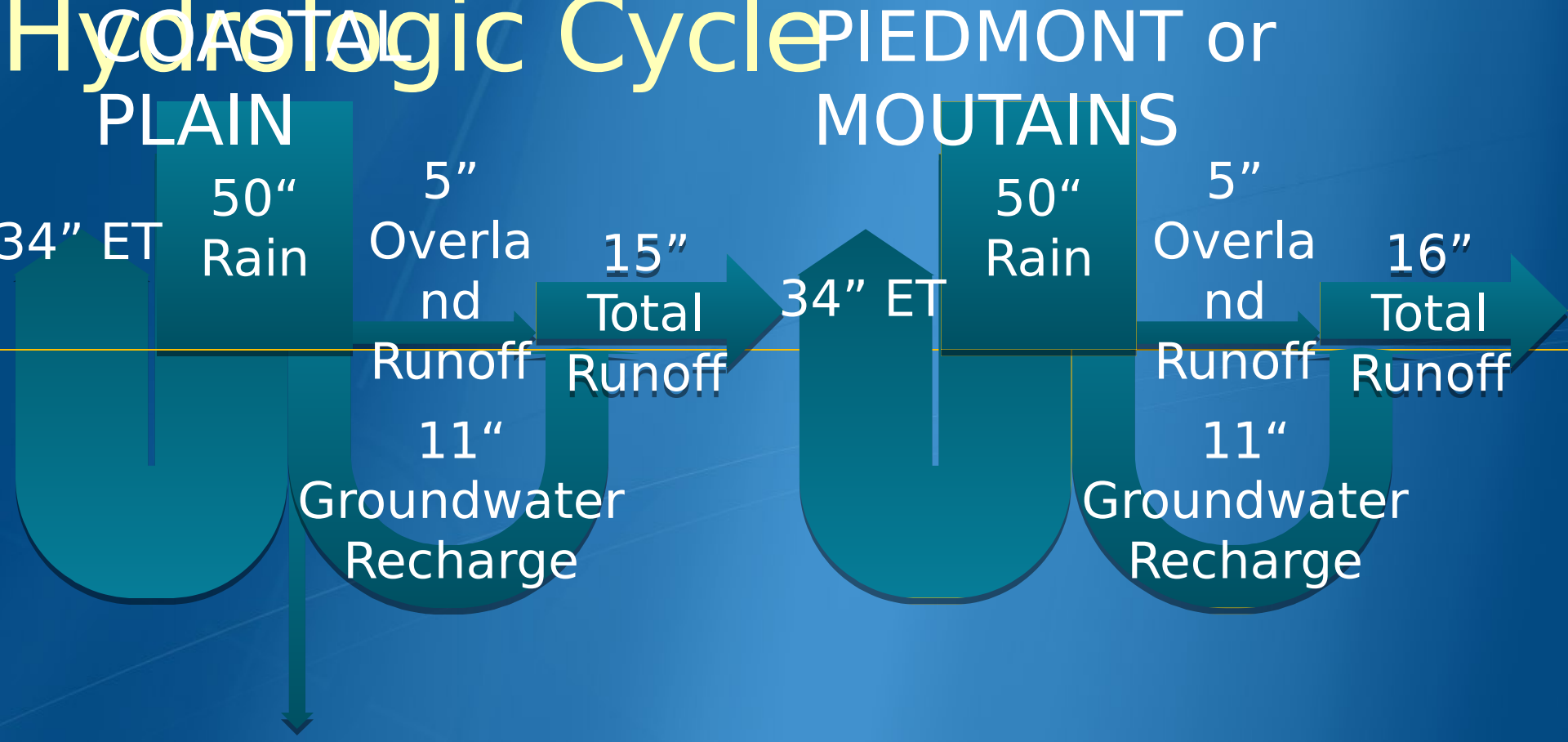




Seawater: >30 ppt

# Groundwater contamination

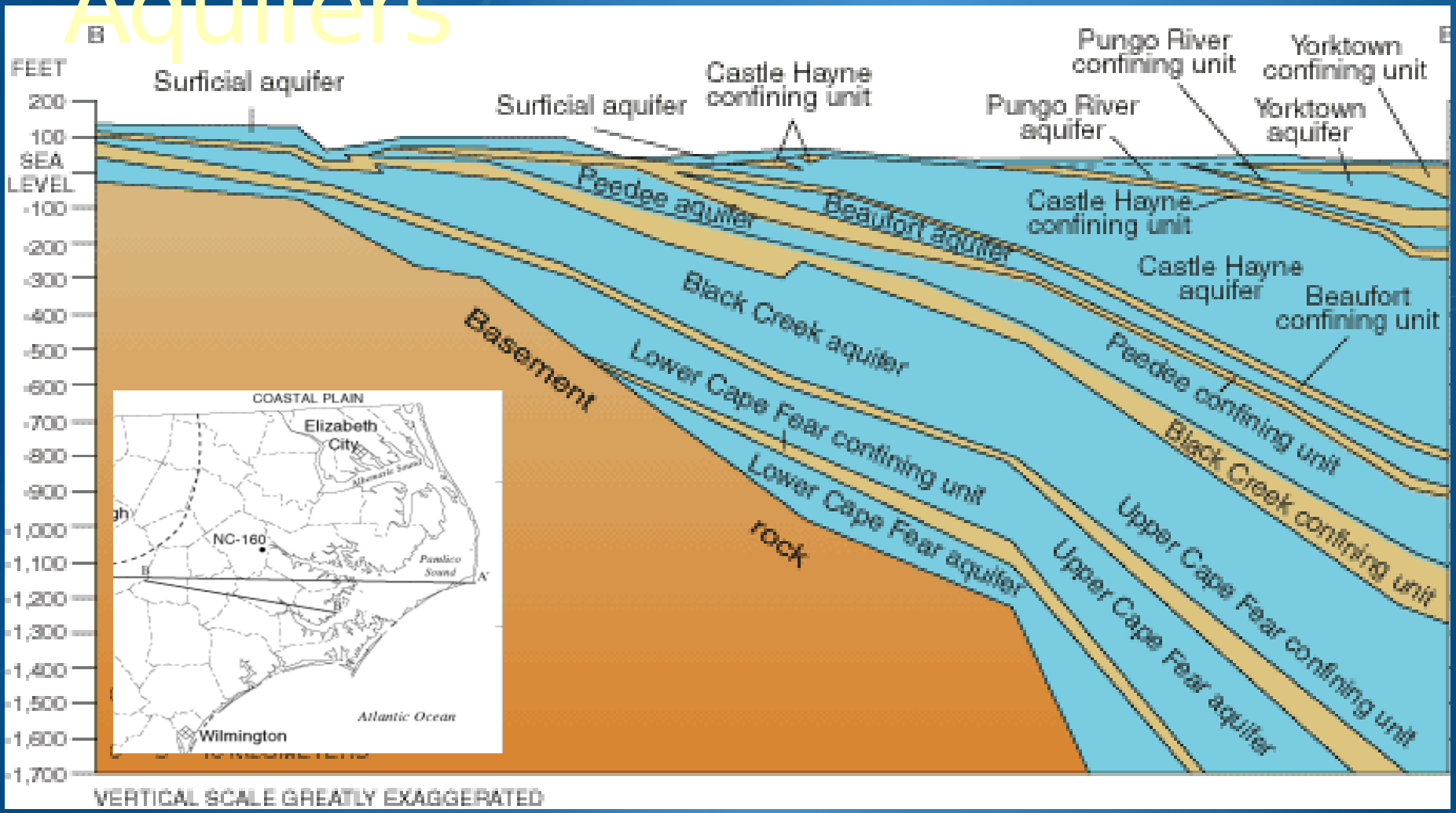
- Sinking a well can lead to groundwater pollution problems
- Other sources and types of contamination include substances such as
  - Gas and oil
  - Highway salt
  - Fertilizers
  - Pesticides
  - Chemical and industrial materials

# North Carolina Natural Hydrologic Cycle




Modified from Wilder, H.B., Robinson, T. M., and Lindskov, K. L., 1978. Water Resources of Northeast North Carolina. USGS Water

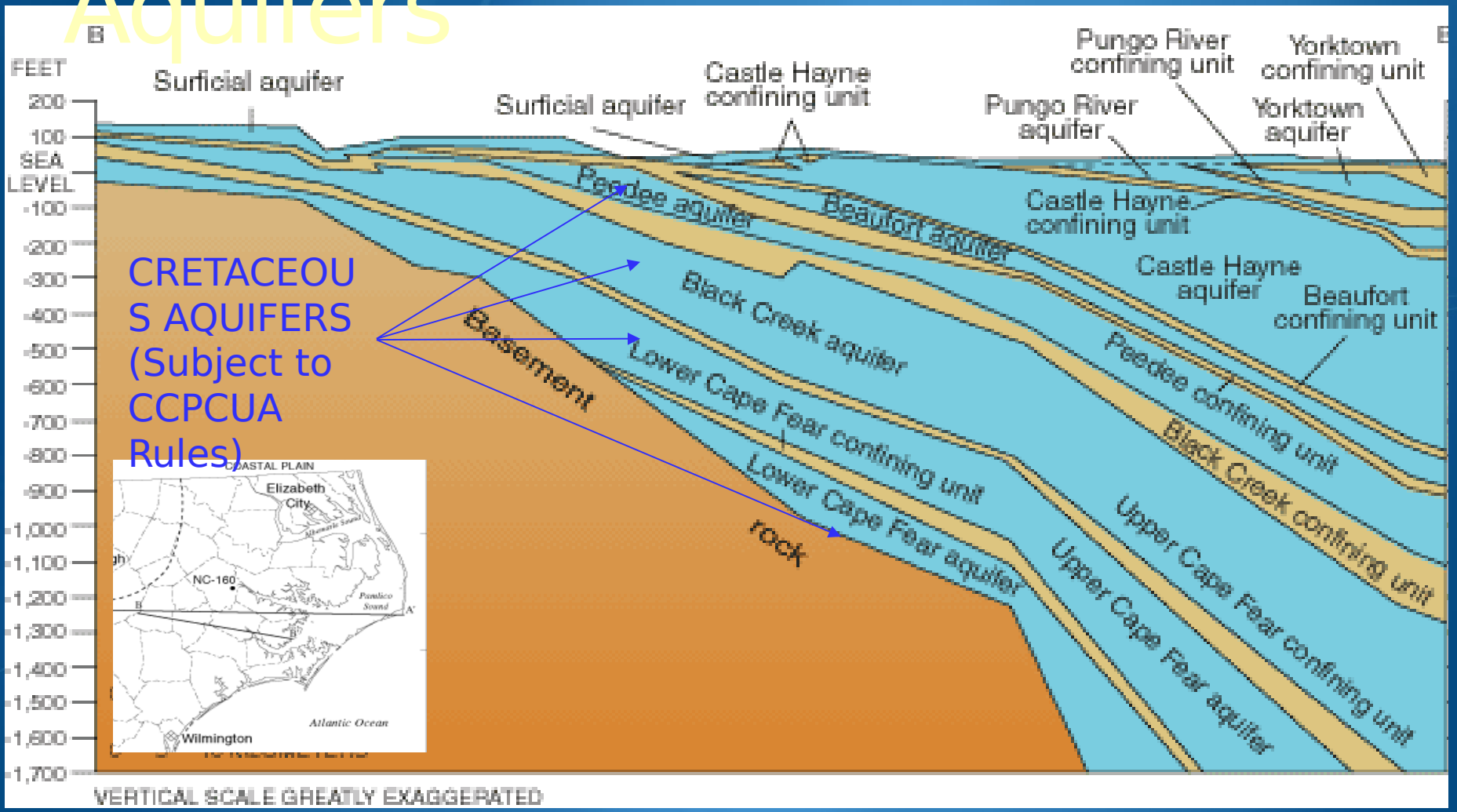
# Eastern North Carolina Aquifers

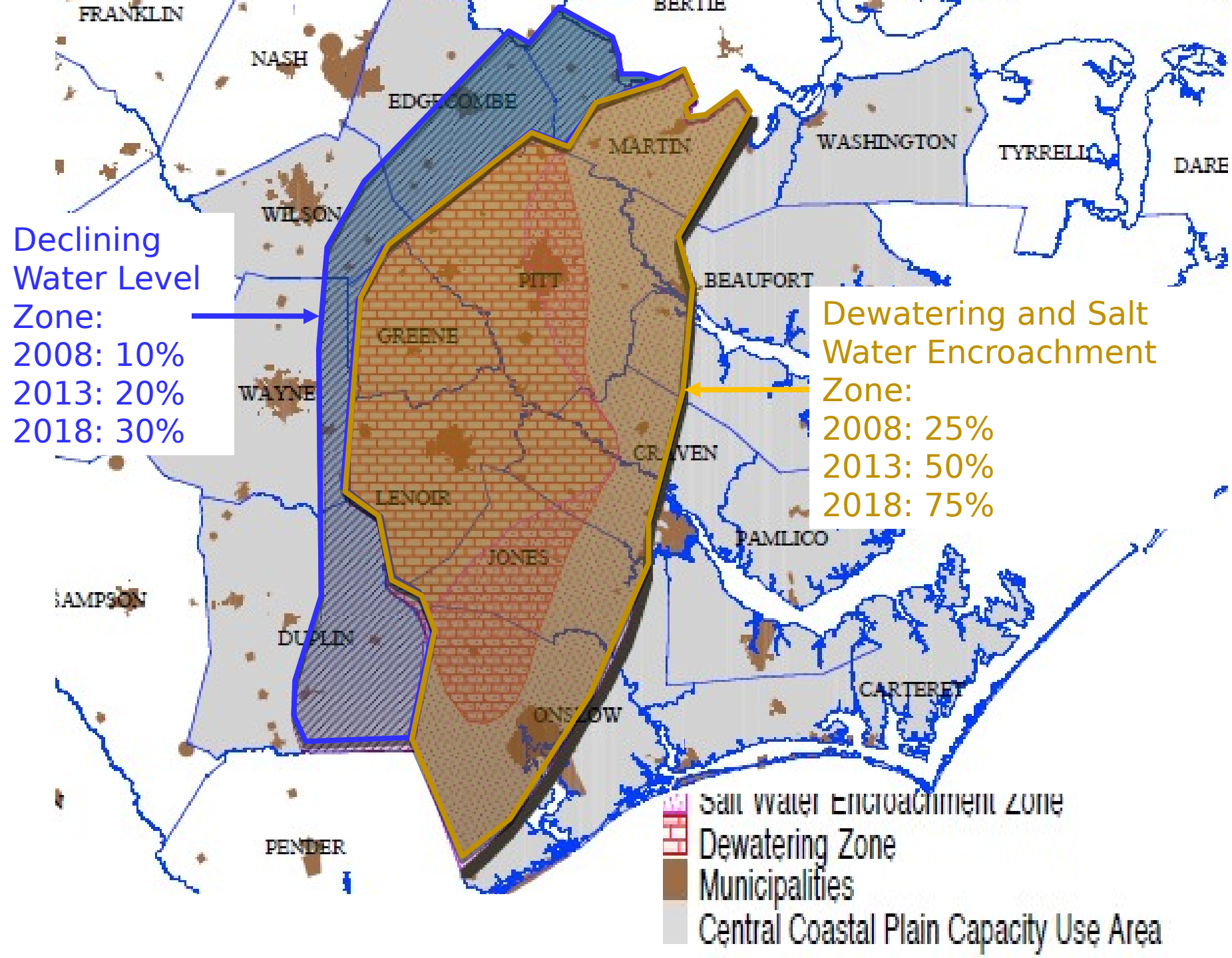


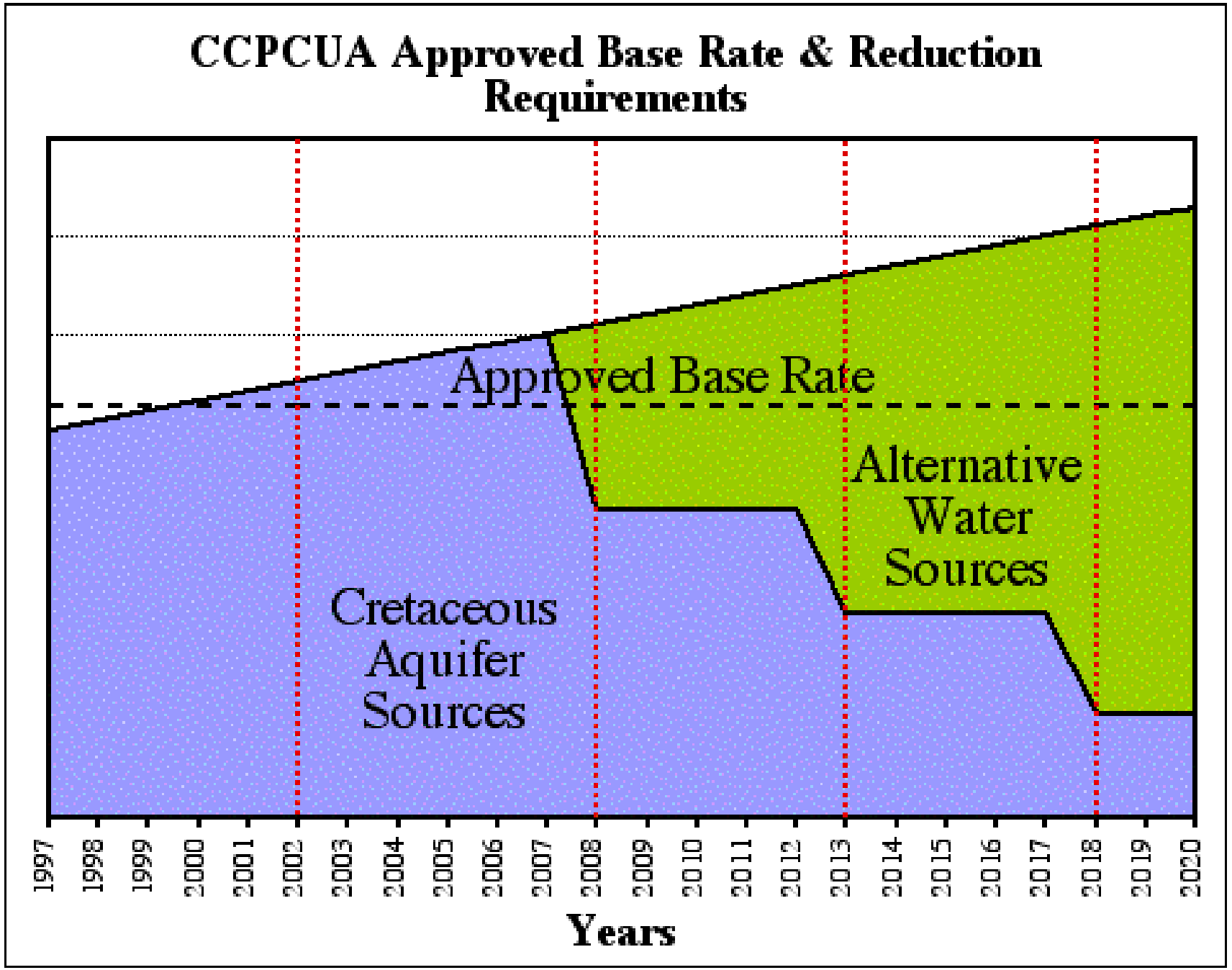
# Central Coastal Plain Capacity Use Area

- 1970’s – 1980’s – Aquifer levels declining, wells producing less water
- 1998 – CCPCU Investigative Report
- 1997/1999 – 2000 Approved Base Rate
- 2001 – CCPCUA Approved
- 2002 – CCPCUA Rules Effective
  - > 10,000 gpd withdrawals

# Eastern North Carolina Aquifers




Declining Water Level Zone:
2008: 10%
2013: 20%
2018: 30%
Dewatering and Salt Water Encroachment Zone:
2008: 25%
2013: 50%
2018: 75%
FRANKLIN
NASH
EDGECOMBE
MARTIN
WASHINGTON
TYRRELL
DARE
WILSON
PITT
BEAUFORT
GREENE
WAYNE
LENOIR
JONES
PAMLICO
DUPLIN
CARTERET
ONSLOW
PENDER
Salt Water Encroachment Zone
Dewatering Zone
Municipalities
Central Coastal Plain Capacity Use Area


CCPCUA Approved Base Rate & Reduction Requirements
Approved Base Rate
Alternative Water Sources
Cretaceous Aquifer Sources
1997
1998
1999
2000
2001
2002
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2007
2008
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2011
2012
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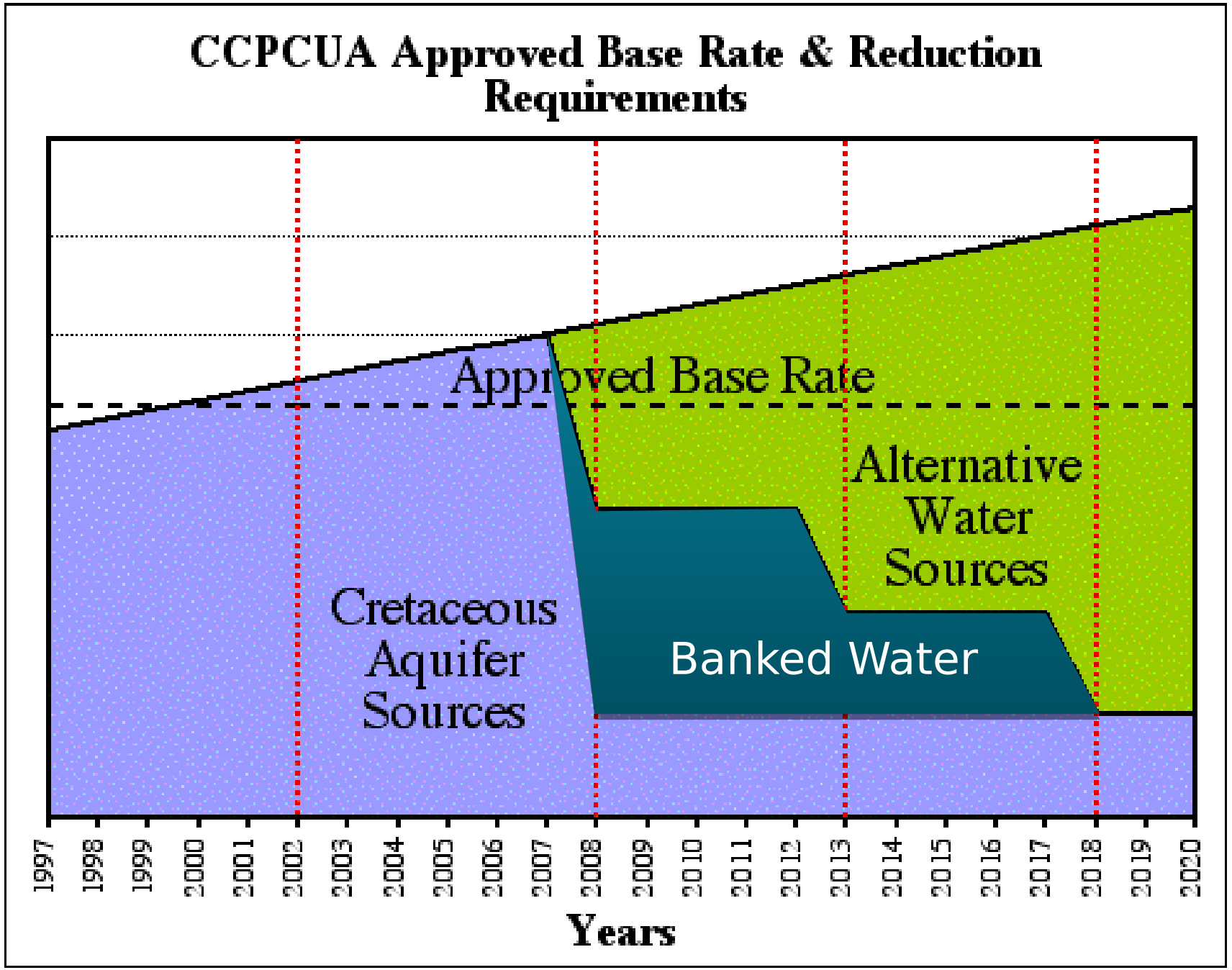
2014
2015
2016
2017
2018
2019
2020
Years


CCPCUA Approved Base Rate & Reduction Requirements
Approved Base Rate
Alternative Water Sources
Cretaceous Aquifer Sources
Banked Water
1997
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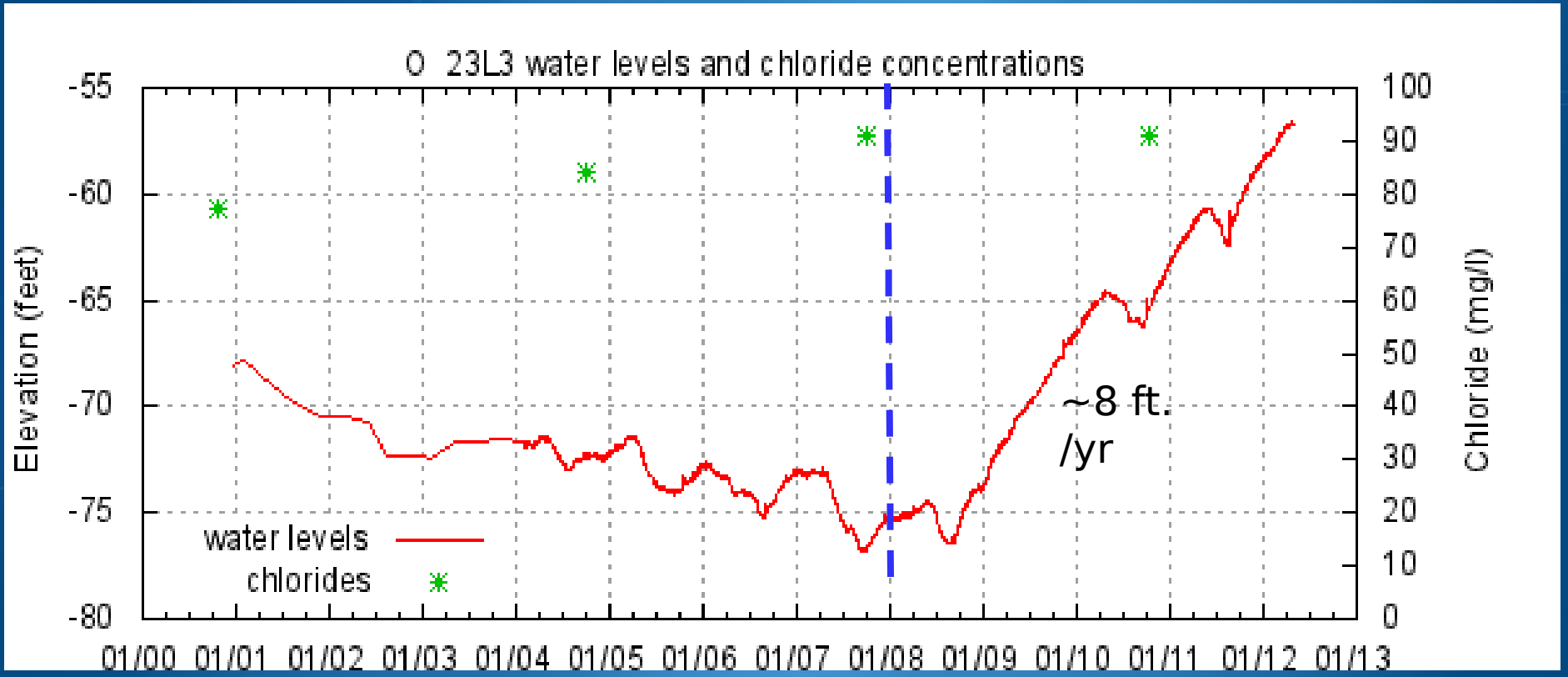
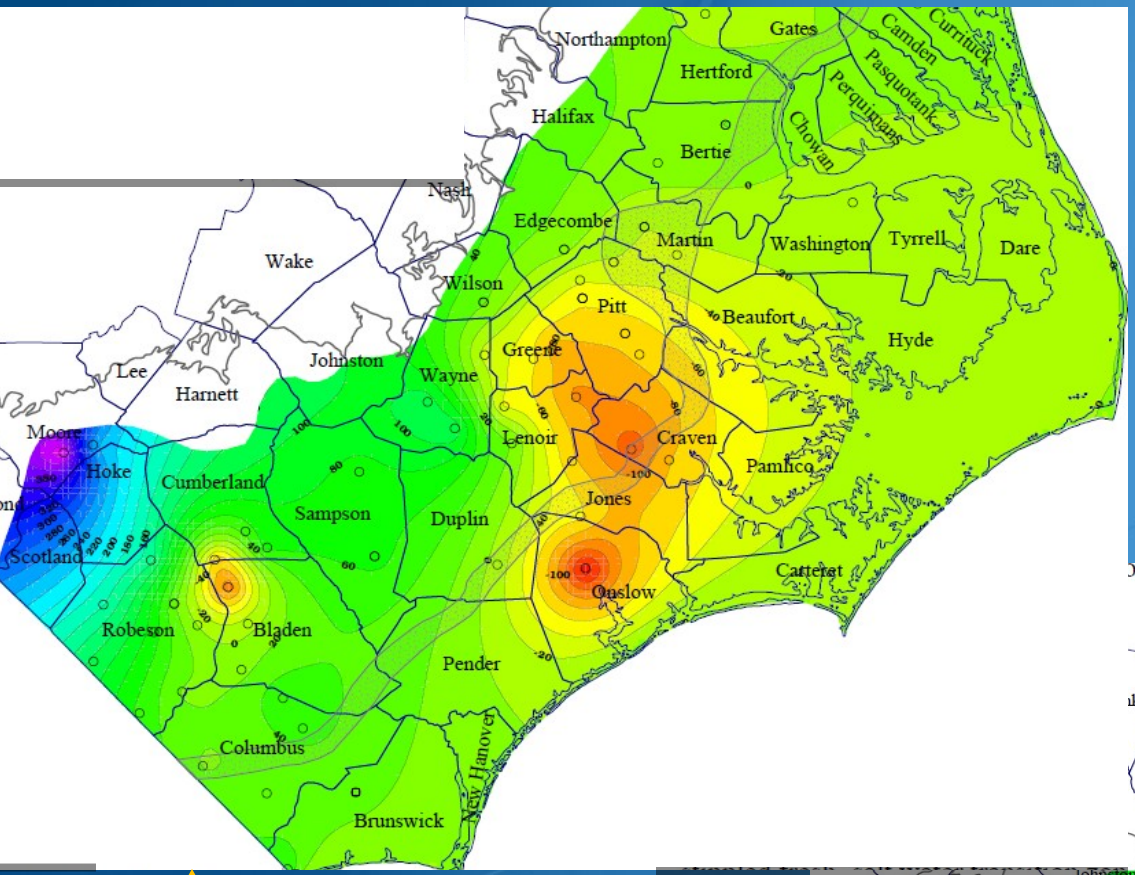
2019
2020
Years

# Greenville

- Tar River
- Aquifer Storage and Recovery

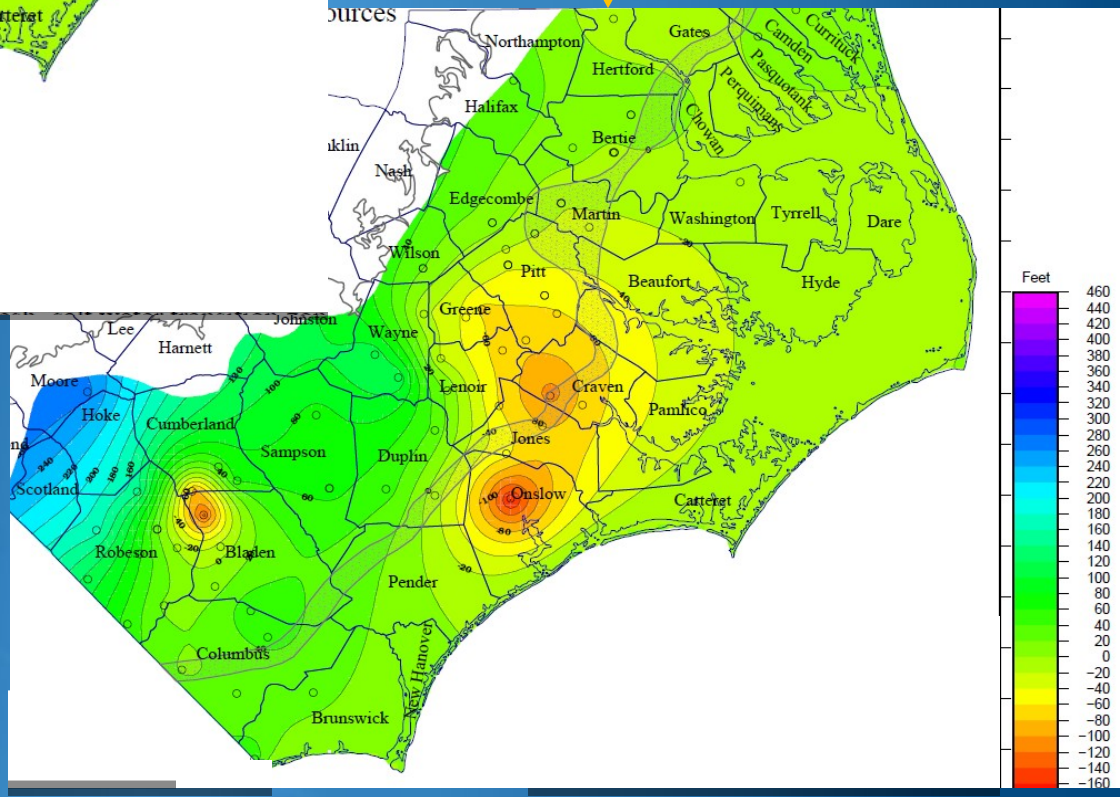


# Upper Cape Fear Aquifer



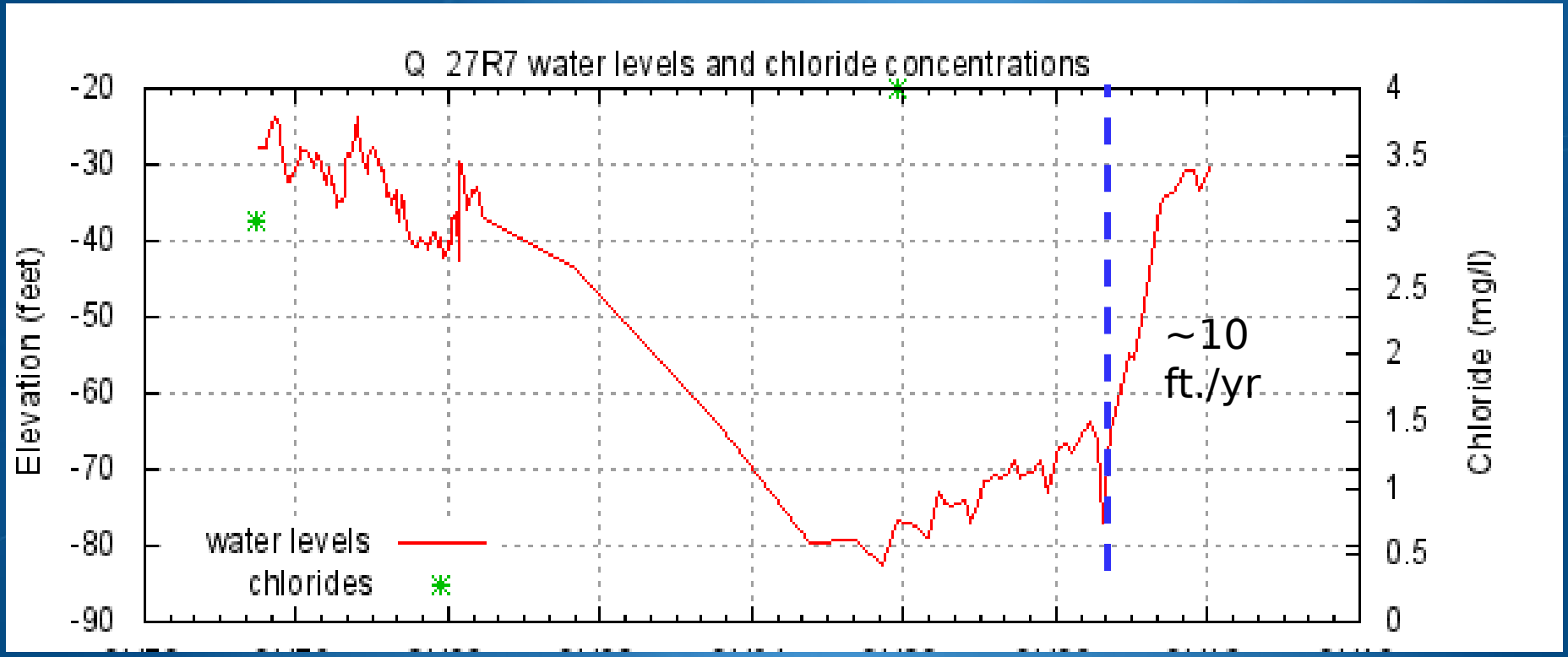

2007

2011



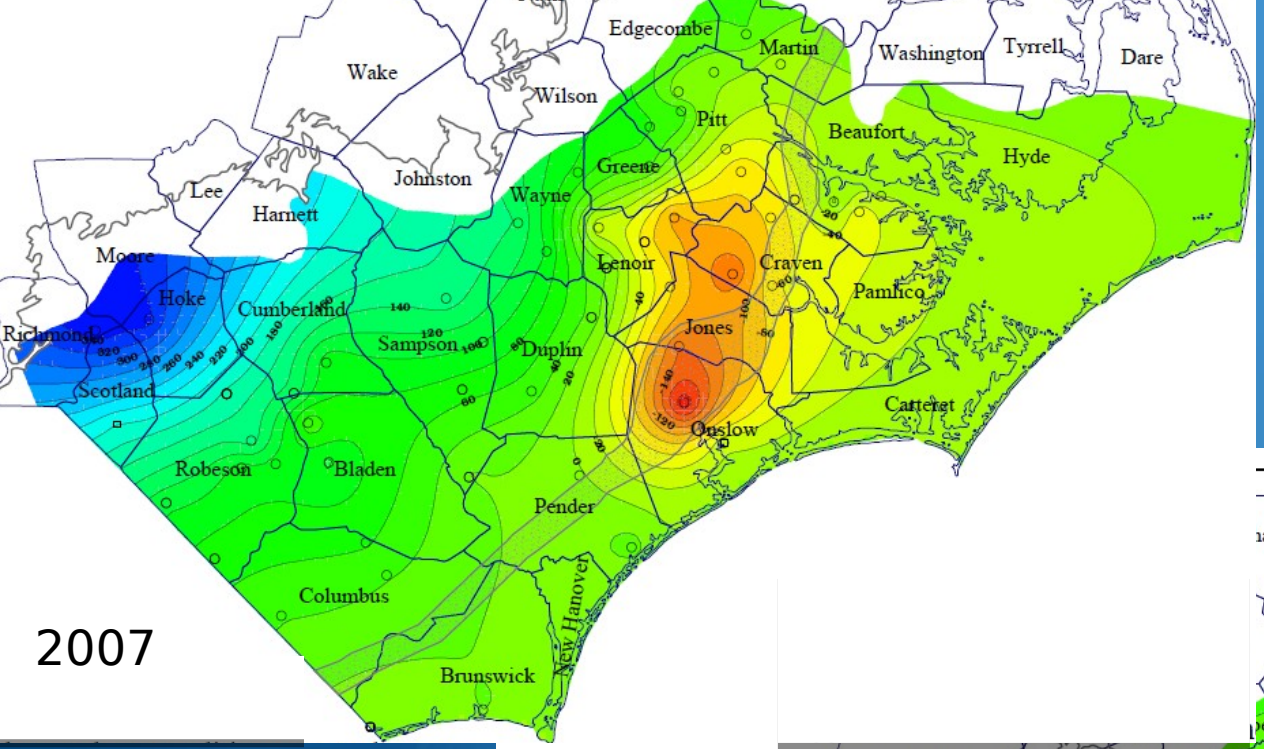
# Kinston

- Kinston Neuse River

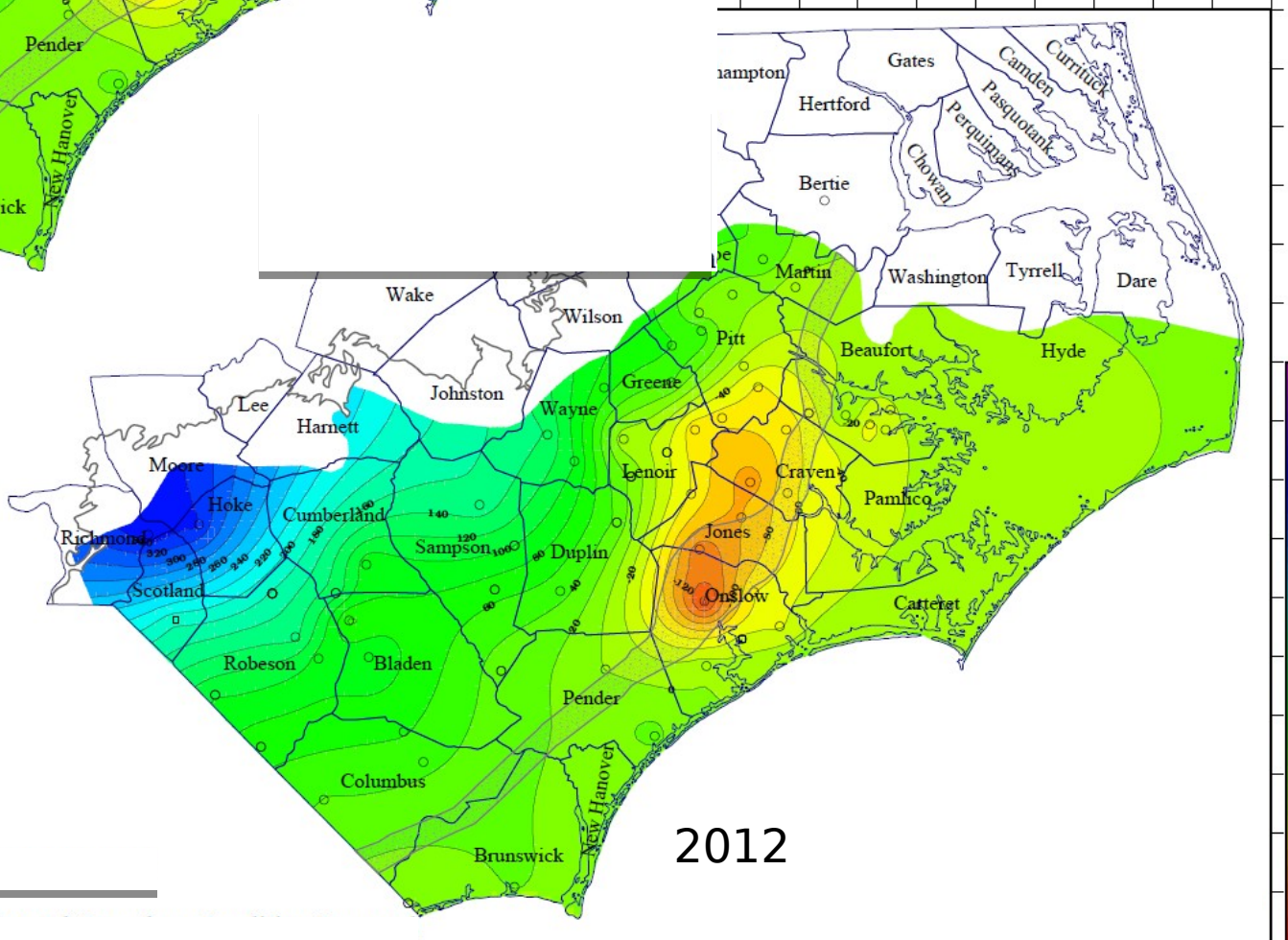



Black Creek Aquifer

# Black Creek Aquifer



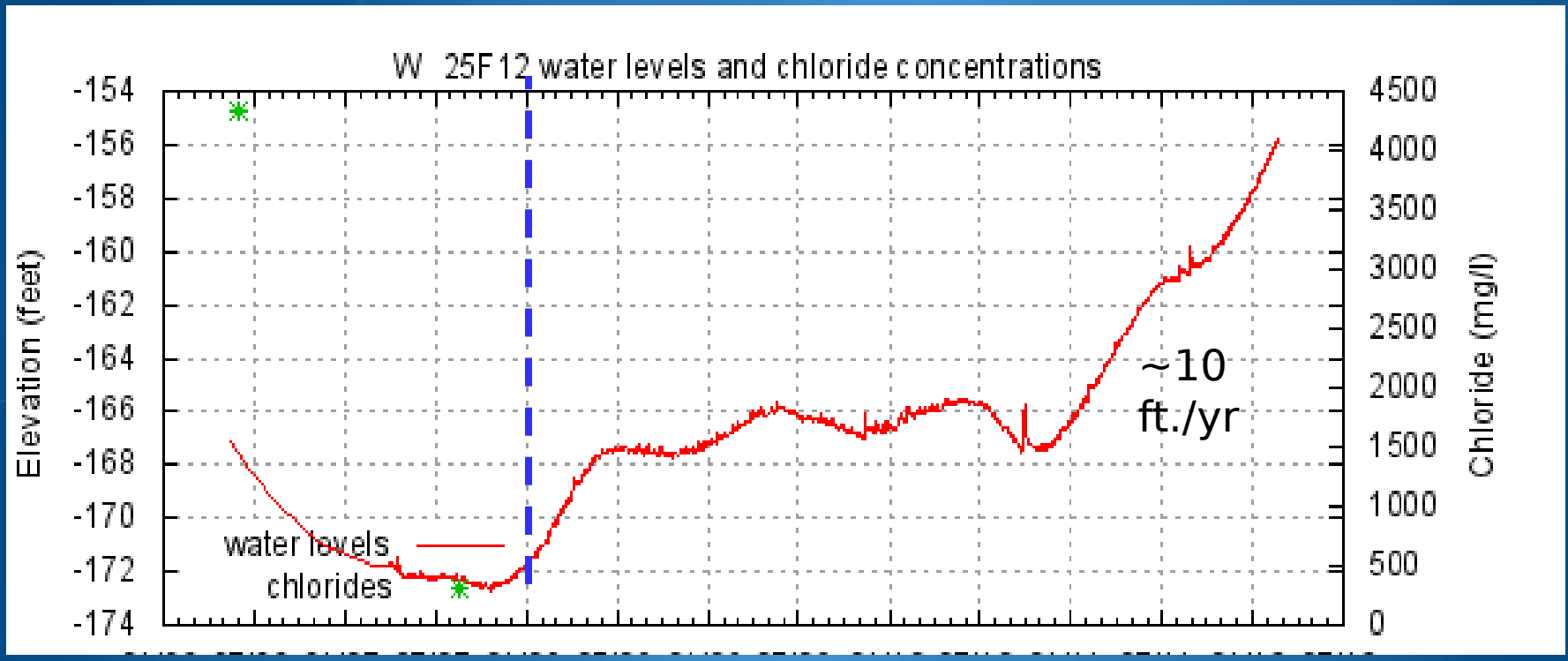

2007



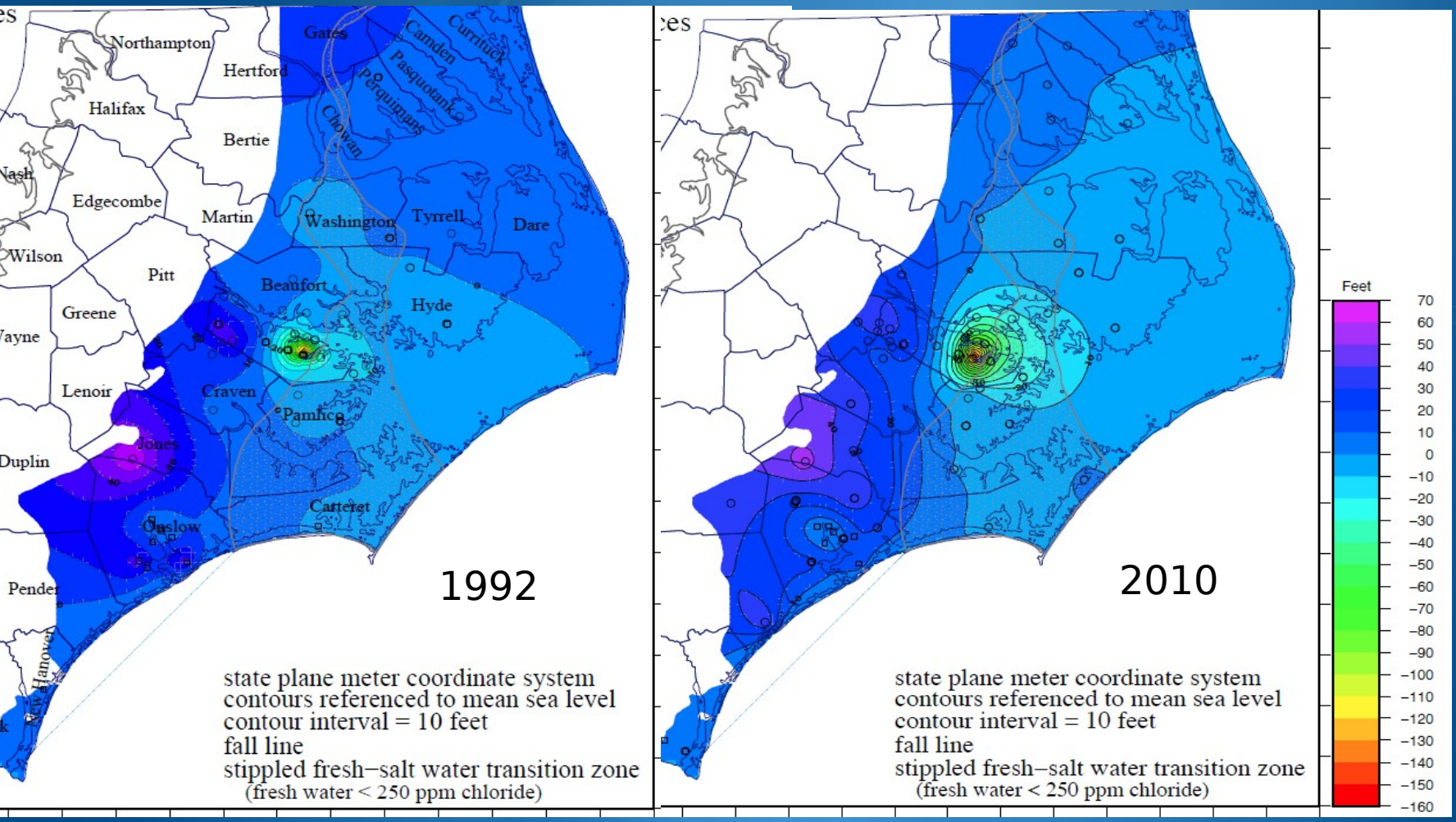

2012

# Jacksonville

- Jacksonville Castle Hayne & Peedee Aquifers



# Castle Hayne Aquifer

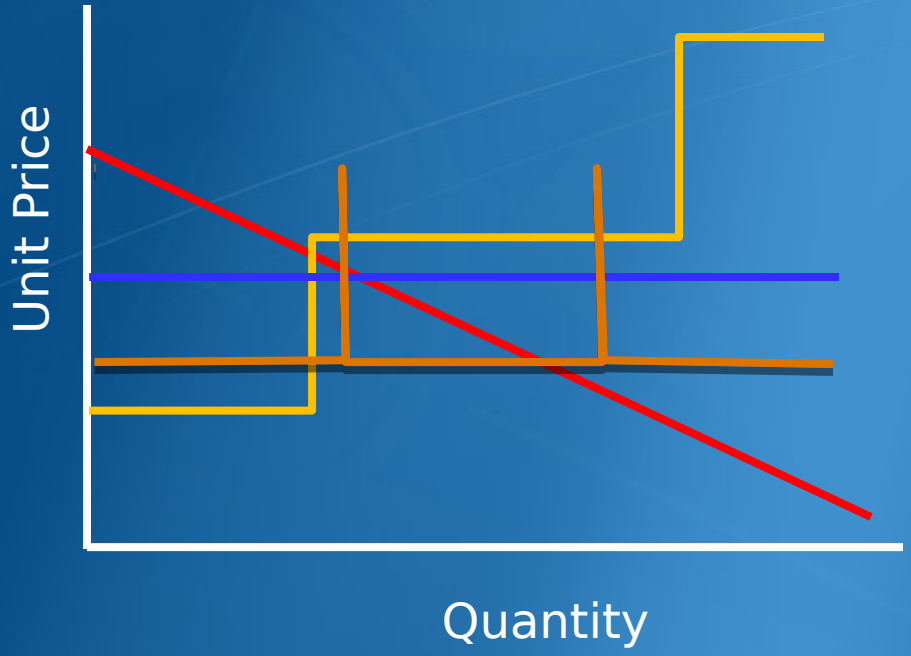


# Water Conservation Principles – Think in Terms of the 3 “R’s”

- Reduce (Best)
  - First and foremost, use less water overall
    - Indoors: low flow fixtures, home run plumbing, etc.
    - Outdoors: native drought-tolerant landscaping, soil moisture sensors, micro-irrigation, etc.
- Reuse (Better)
  - Second, minimize potable water use via reuse
    - Stormwater reuse
    - Graywater reuse (rooftops, cisterns, shower/bath/sinks, etc.)
- Recycle (Good)
  - Lastly, recycle wastewater
    - Dual piped reclaimed water systems

# Public Water Supply System Requirements

"Adopt water conservation-based rate structure, such as: flat rates, increasing block rates, seasonal rates, or quantity-based surcharges."



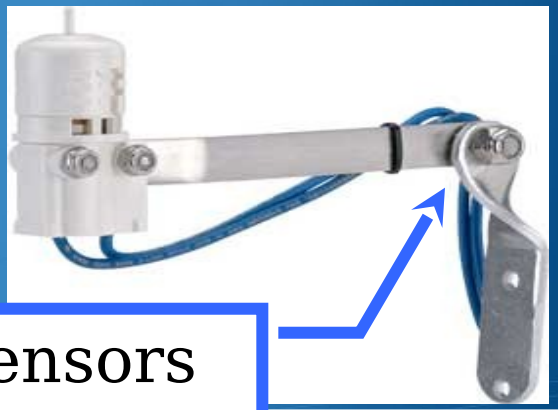
# Public Water Supply System Requirements

"Adopt water conservation ordinance for irrigation, including such measures as:  time-of-day and day-of-week restrictions on lawn and ornamental irrigation, automatic irrigation system shut-off devices or other appropriate measures."

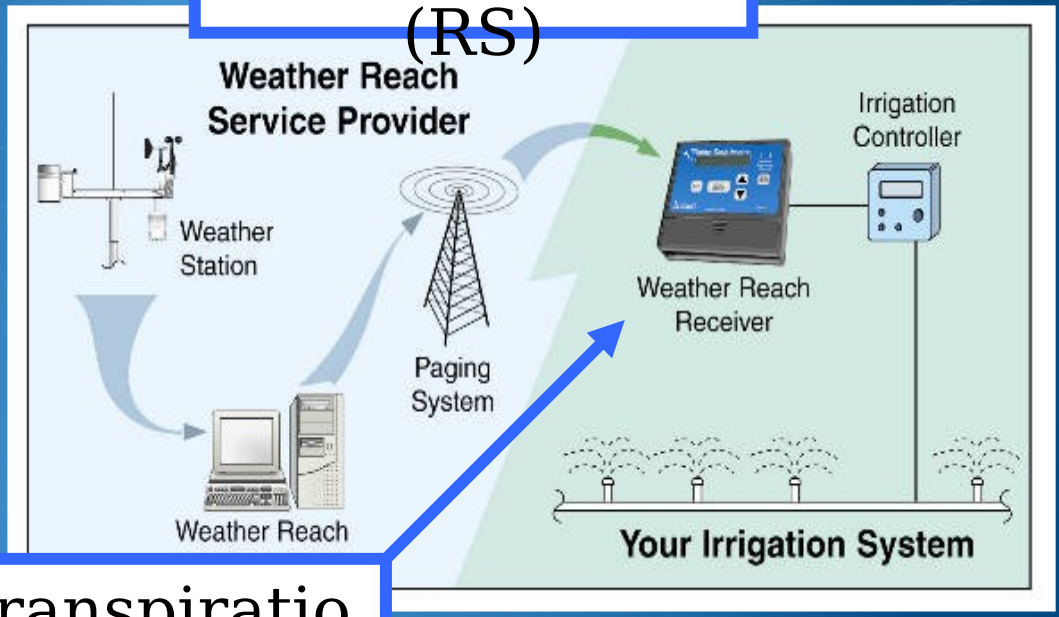
- Lawns are most irrigated crop
- Half of home's water use
- Municipalities limit turfgrass area

# Sensor-Based Irrigation

Soil Moisture Sensors (SMSs)



Rain Sensors (RS)



Evapotranspiration (ET) Controllers

# Public Water Supply System Requirements

"Implement a retrofit program that makes available indoor water conservation devices to customers (such as showerheads, toilet flappers, and faucet aerators)."

# Residential Water Demands

# Indoor Water Use

| USE | Gal/Person/Day* | Percentage of Total |
|---|---|---|
| Faucets | 10.8 | 23.9% |
| Clothes Washing | 10.0 | 22.1% |
| Showers | 8.8 | 19.5% |
| Toilets | 8.2 | 18.0% |
| Leaks | 4.0 | 8.8% |
| Baths | 1.2 | 2.7% |
| Dishwashers | 0.7 | 1.5% |
| Other Uses | 1.6 | 3.4% |
| Total | 45.2 | 100.0% |

*Water Conservation Values (e.g. low flow toilets, showers)

Handbook of Water Use Conservation, Amy Vickers
Residential End Uses of Water: WERF, 1999

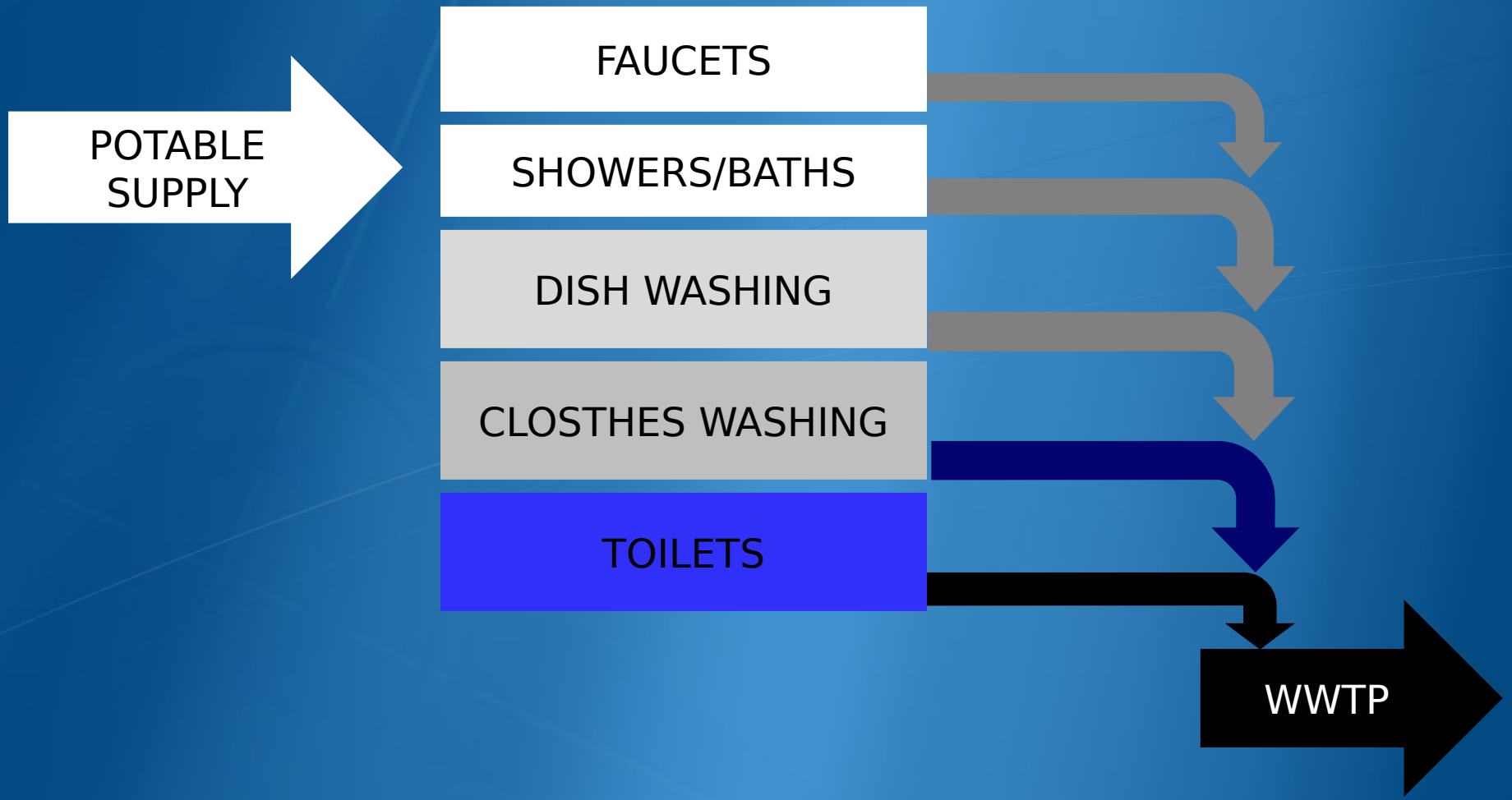
45.2 Gal/Person/Day * 365 days * 2.5 people = 41,245 Gal/yr.

# Public Water Supply System Requirements

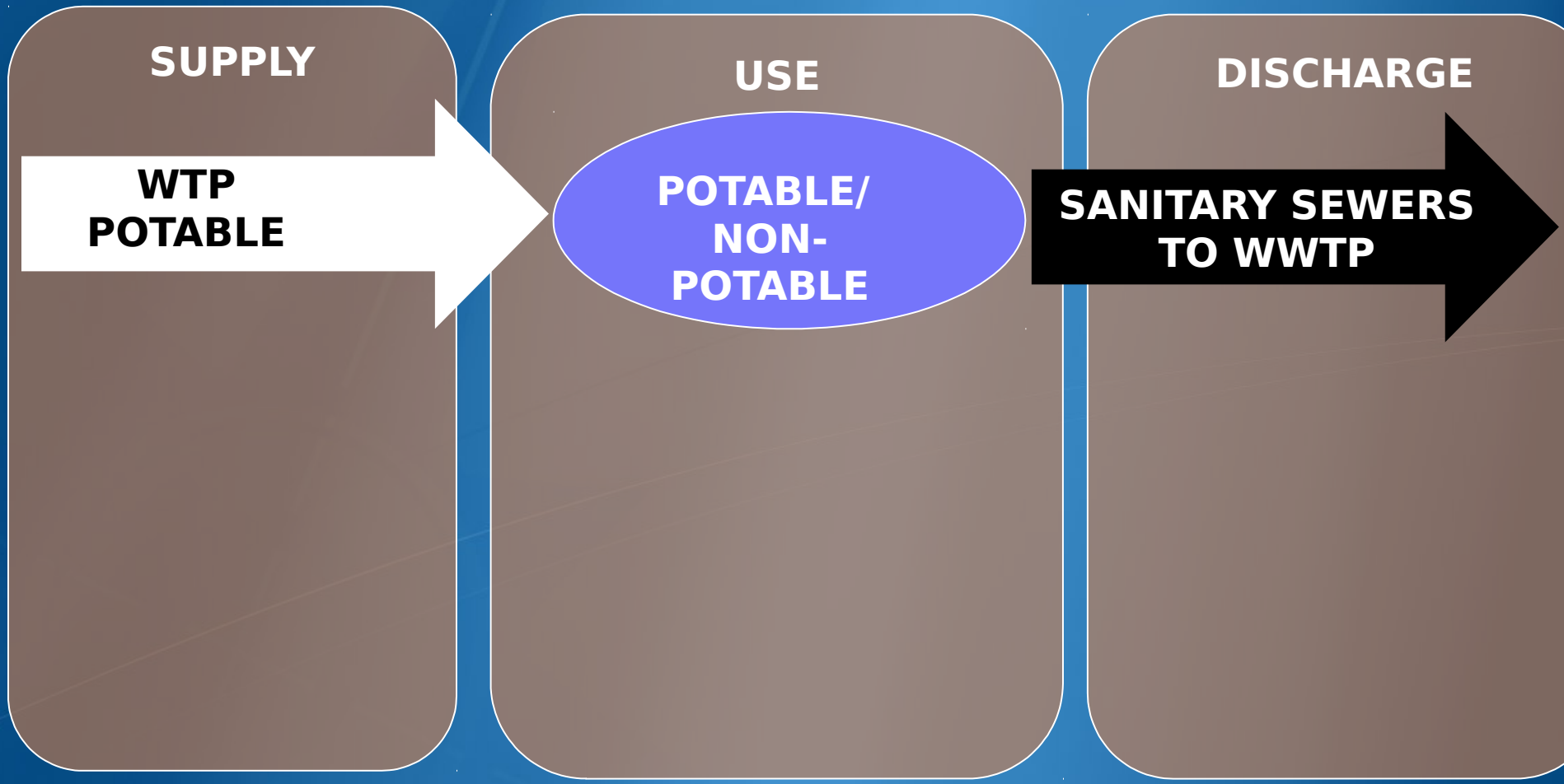
"Evaluate the feasibility of water reuse as a means of conservation, where applicable"

- Reclaimed water system
  - Gray Water (Purple Pipe/Dual Pipe)
- Stormwater Reuse

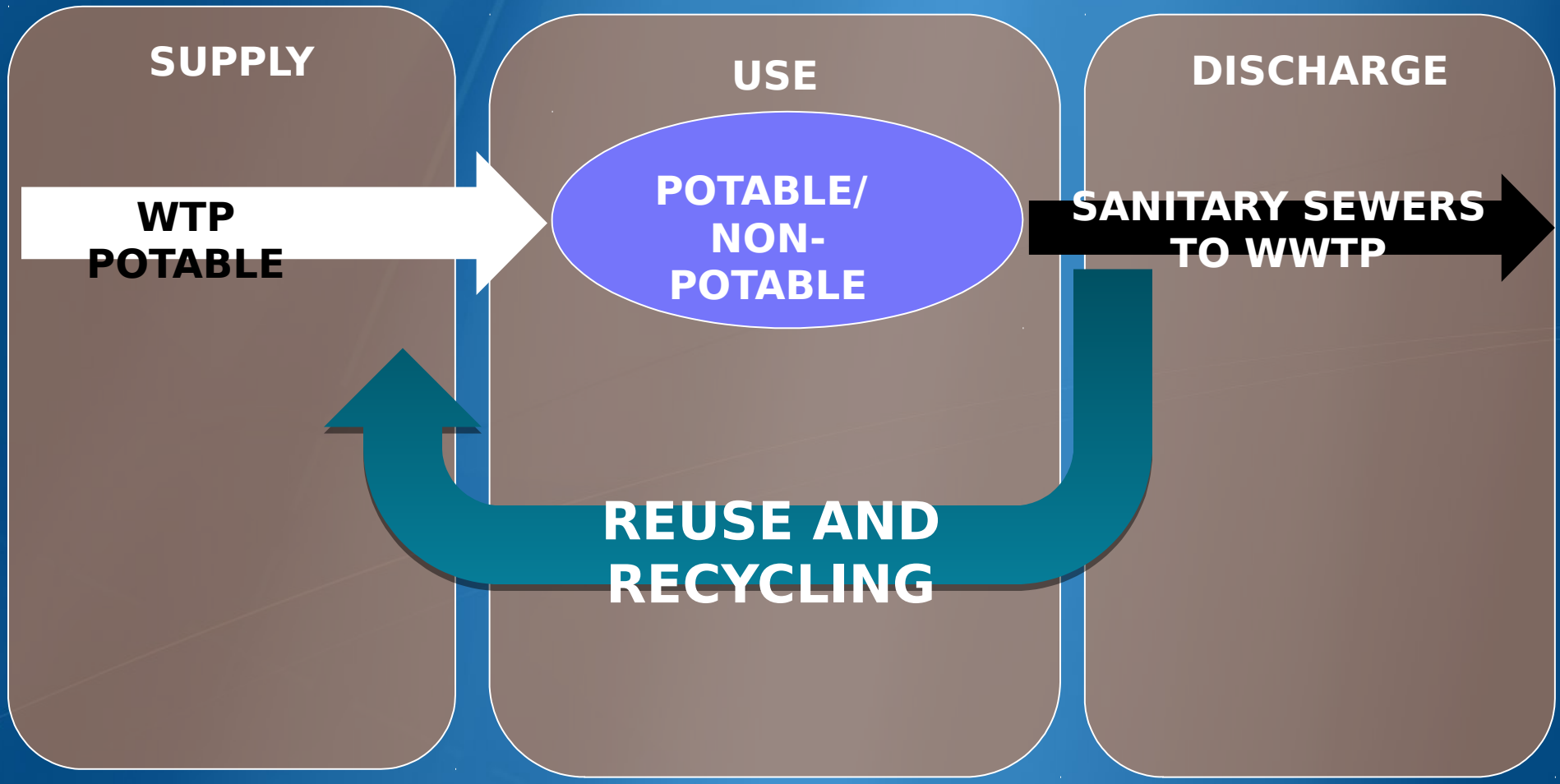
# Indoor Water Balance



# Typical Indoor Water Balance



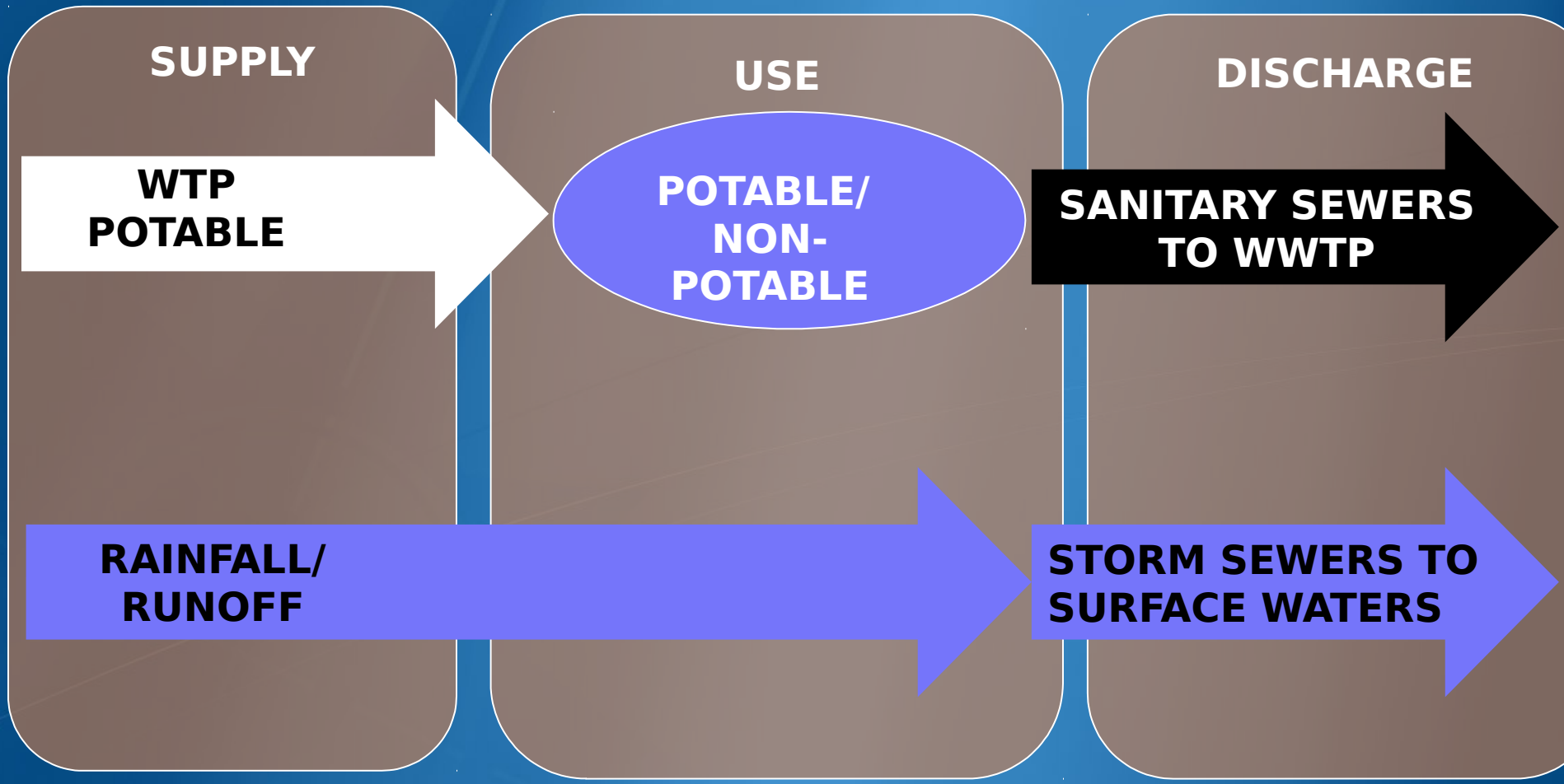
# Sustainable Indoor Water Balance



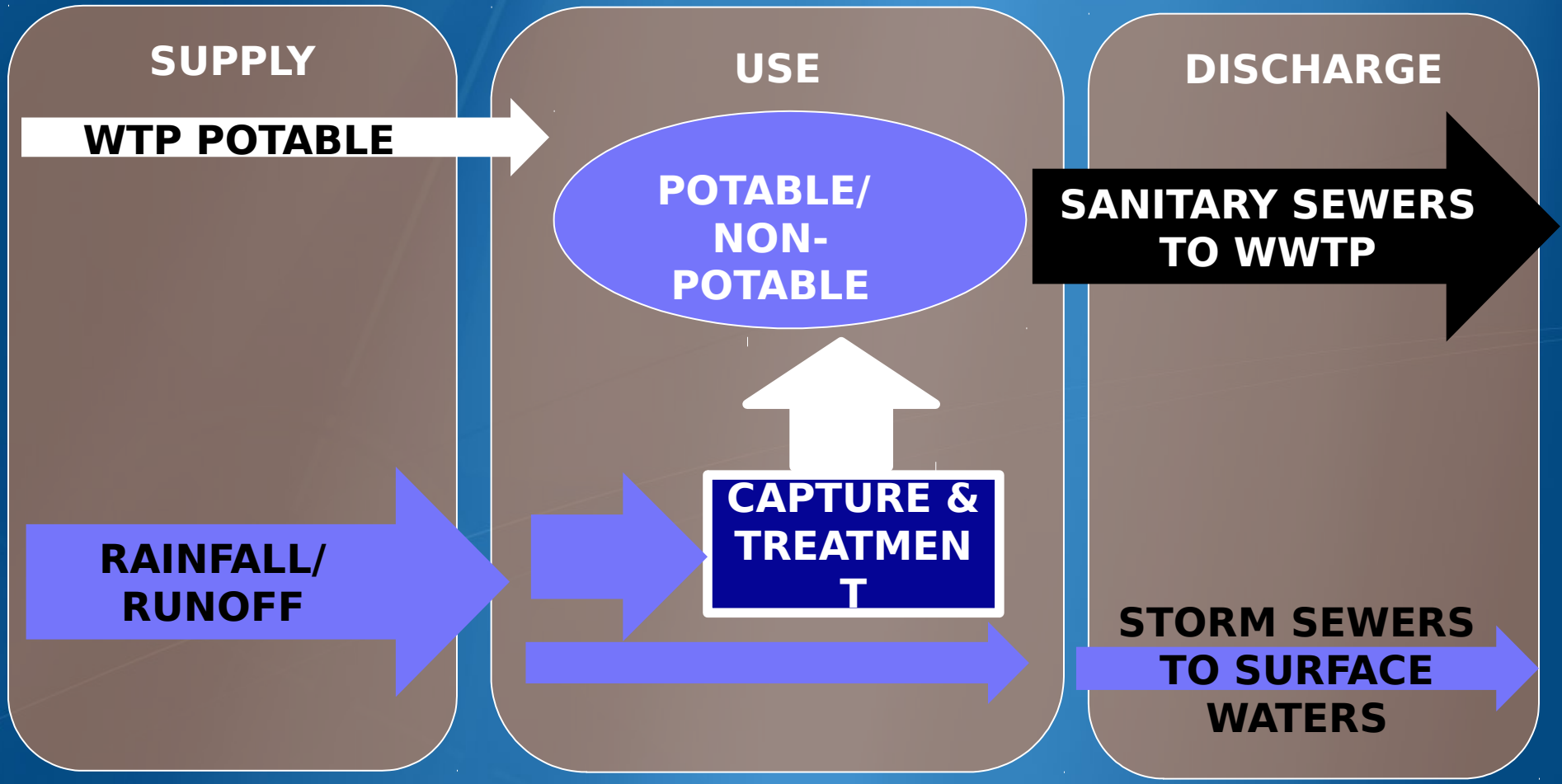
# Cisterns

- Under or Above Ground
- Detains Runoff
- Recovers Storage by Use
- Relatively Small Foot Print
  - Great Retrofit Optic

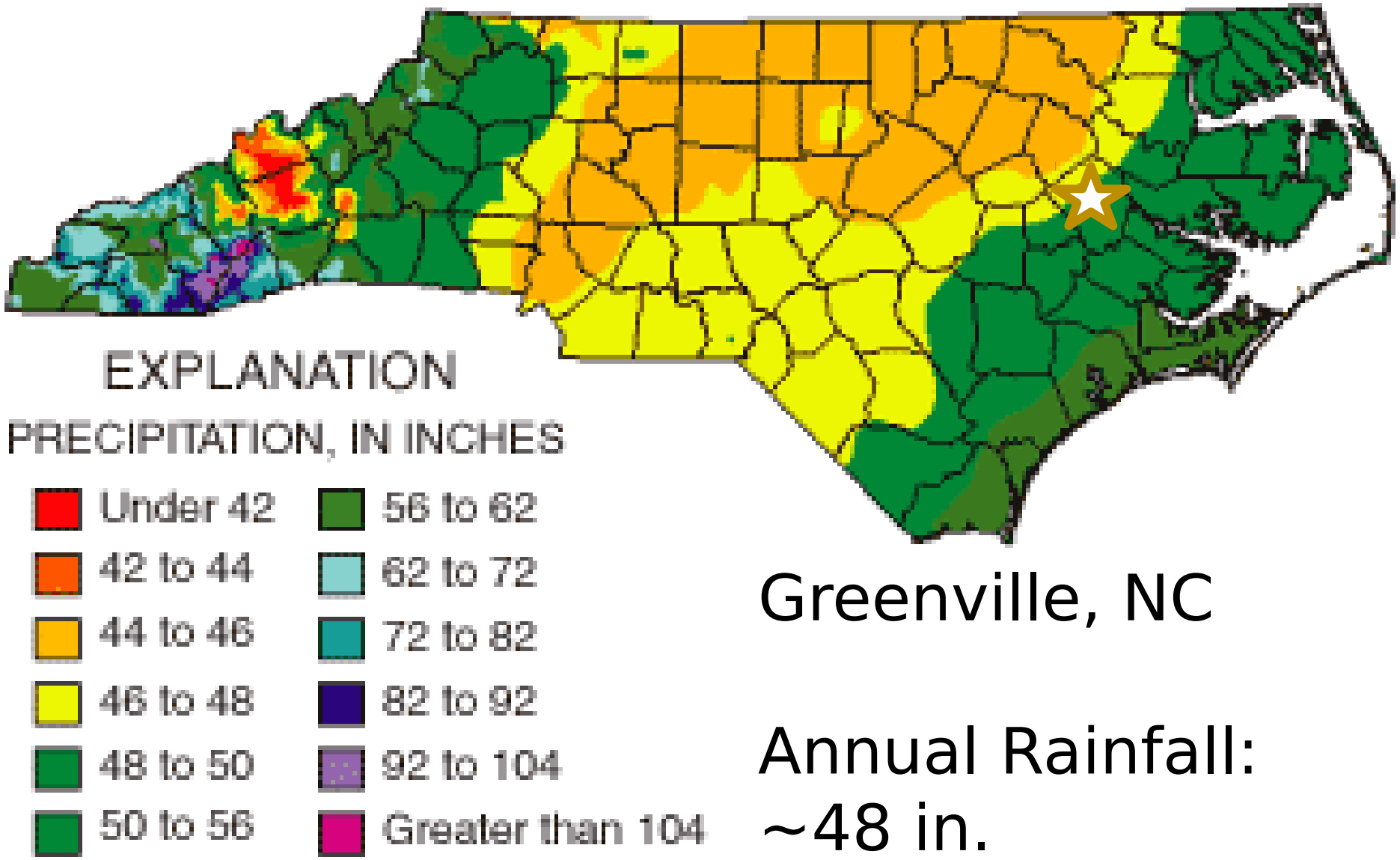
# Conventional Site Water Balance



# Sustainable Site Water Balance



# Supply Quantity




Greenville, NC

Annual Rainfall:
~48 in.

# Supply Quantity

- Roof Area: 2000 $ft^2$
- Annual Rainfall: ~48 in.
- Annual Roof Runoff Volume:
  - ~50,000 gal/yr.
- Capture Efficiency (80%):
  - ~40,000 gal/yr.

2.5 people = 41,245 Gal/yr.

# Thank You

*"We are not running out of water….we're running out of CHEAP water"*

- Florida Water Management District Official

Eban Bean, PhD
beaneb@ecu.edu
Engineering Department